And Just How DO You Kill A Weed?

Subject: Life science, Research & Experimental Design

Grade: 6-8

Lesson Topic: Plant growth and Regeneration

Length: ~6 weeks

Learner Objective:

The students will be able to describe how both seeds *and fruits* help with seed dispersal.
Students will investigate other means for plants to regenerate besides seeds
The students will be able to explain chemical, cultural and biological weed control methods.
The students will design and conduct an experiment to simulate a weed control method.
Through their experiments students will understand various ways to prevent weed dispersal and the problems of applying "one solution."
The students will be introduced to the idea of Integrated Pest Management (IPM)

Introduction:

It is important to remember that controlling alien plant species is a response to biological pollution, to a problem that will persist unless restoration of a healthy environment also becomes part of the solution. Pulling weeds may slow the *spread* of weeds, but it does not alter the conditions that first favored the invasion. Students who participate in NatureMapping, the capstone unit of *Aliens In Your Neighborhood*, contribute valuable information about the entire ecosystem affected by alien weeds. By understanding the complex web of interactions, land managers may better prescribe a combination of control methods that eliminate the alien species, as well as, obtain from the students valuable information for the restoration of the land.

Content:

Alien weed species have the advantage of few natural enemies and an ability to persist in a wide range of habitat and environmental conditions. For these reasons, it is rare that a single method of control is effective... as any child will tell you, after being told to weed the garden, it is a job that never seems to go away! Besides hand pulling, land managers have a variety of other means for controlling invasive weeds – chemical, biological, mechanical and fire (refer to the Control Unit introduction for a detailed explanation of these methods).

In this activity, students will become familiar with the process of experimental design as they create innovative solutions to controlling invasive weed species. Land managers often use a combination of several methods, especially when the combination can narrow the range of impact to other species, i.e., when the control method is host-specific. But many unanswered questions remain about how best to control invasive

species, and, it can be assumed, there are probably as many solutions as invasive plants have adaptations to thwart our efforts. Your students will have the opportunity to explore and invent some possible solutions… who knows, maybe some of them will create solutions which will be adopted by land managers, and thus, turn their education into a meaningful contribution as citizen scientists.

Many students interested in science are anxious to "do science in the field" because the media typically reports the more exciting aspects of field work in exotic places, often under difficult conditions. What they fail to report is all the research, often years of it, which must form the foundation of the fieldwork. In this activity students will perform basic research on what is currently known about the invasive weed of their choice, and then design an experiment and hypothesis to investigate their own ideas. The activity begins, as with all investigations, with an "I Wonder…" statement, for example, "If cheatgrass isn't killed by a forest fire, I wonder if freezing it would work?" Short of detonating nuclear devices, I would allow ideas as broad and as wild as a young mind could create (actually, I've had this discussion with students and we hypothesized that some invasive plants would even survive a nuclear blast, but we lacked the resources (and security clearance!) to carry out an experiment).

After the "I Wonder" statement the students should be guided through the Experiment Design Form. The most difficult aspect of experimental design is refining the question. When we wonder, we tend to do so broadly and hence we inadvertently include a great number of variables that make it difficult to answer our question. Doing research on our question is often helpful in refining the question. For example, we may ask the question, "Why is the sky blue?" Seemingly a simple question, but upon examination we find a need to define what we mean by "sky" and what exactly is "blue?" After research we may have a better understanding of the layers of atmosphere, particulate matter (dust) suspended in different quantities at different altitudes, the reflective properties of those particles, the physics of light waves, the wavelengths emanating from the sun, the angle of light to our perspective on the surface of the earth, and the splitting of wavelengths by angles of entry and particles struck. Having done all that research we would be in much better position to design an experiment that could simulate a blue sky, and so answer the original question of wonder.

The second most difficult aspect of designing an experiment is defining the variables; the independent variable (the thing being manipulated, ex. temperature), the dependent variable (the thing you believe will respond to the independent variable, ex. germination rate), the controlled variables (those things you hold constant, ex. humidity) and the control (the "normal" situation without manipulating variables so you have something to compare your results against). Students must have done a certain amount of research before they can start imaging the variables. The more time you can assist them in refining their question, the easier it will be to determine, and limit the variables (the fewer the variables in an experiment, the less chance for error, and by extension, the more reliable the data).

Materials and Supplies:

Living invasive plants and/or seed from a variety of aliens in your neighborhood.
A set-up with Gro-lux lights to grow plants, small greenhouse, or solar frame
Weed Journals (or have the students make an Experiment Notebook)
The following forms are included in this lesson:
Teacher's Outline for a Student-Based Inquiry, *with suggested time frames*
Design An Experiment Form
Student Experiment Notebook Check-off List
Assessment Rubrics

Students will be designing their own experiments, so the materials will vary. Complete materials and procedures outlines are essential elements of experimental design and students should gain approval for their materials list and procedures before being allowed to continue.

Anticipatory Set:

Obtain a plant like bindweed (Morning Glory), ivy or some other plant that naturally regenerates from rhizomes, stem sections and tap roots (although an alien weed makes a better point to the activity, it is possible to use more common plants). Make sure the plant is alive and planted in a garden pot, displayed prominently at the beginning of class. Hidden from view, have a tray of moist potting soil that has been "spiked" with a small amount of fertilizer and root hormone (B-1 Root Stimulator® would be great). Ask your students for suggestions on how you might kill the plant and list their (appropriate) suggestions on the board. After making the list, jerk the plant out of the pot and ask how many of the students think you just killed the plant (you'll need to be doing a bit of the violent gardener act here). Break a few limbs off and tear up some leaves. Do any students think it is dead yet? Pull out some scissors and snip the limbs and roots into 2-3" sections and ask the students if they think the plant is dead. At this point pull out the tray of soil, bury all the plant parts about ½" deep, mist the surface thoroughly with water, and as you walk it over to the growing station remark, "Well, it might look dead, but *I sure don't think it's dead*." (In a couple days, after maintaining moisture and a 24 hr. light, you should have new sprouts from the segments of the original plant).

Activity Outline:

The students will design an experiment to "kill" an invasive weed species based upon the list of methods they created during the anticipatory set (or any other appropriate means they may come up with).
Some suggested ways to kill a weed might be (excluding nuclear explosions):

- ❑ Applying chemical treatment (herbicides, fungicides or pesticides)
- ❑ Simulate a wildfire
- ❑ Mechanical destruction (chopping, grinding, etc.)
- ❑ Defoliation
- ❑ Biological control (introducing herbivores or parasites/Integrated Pest Management - IPM)
- ❑ Grazing (have a pet goat at school!)

- ❑ Bury them in a compost pile
- ❑ Other?

Live plants may be transplanted from the field or started from seed, depending upon availability and time constraints. Students should record important information concerning their plant in their Weed Journals or Experiment Notebook, including:

- ❑ Species name
- ❑ Date collected or planted
- ❑ Drawings of their plant
- ❑ Identification of plant parts
- ❑ Measurement of plant
- ❑ Other observations taken daily while caring for them until they are ready to begin their experiments.

While caring for their plants the students should be conducting research about their plant and the control methods they are planning to investigate. Follow the guidelines from the Student Experiment Notebook Check-off List to assist students in their research and report writing.

Assist them with filling out the Experiment Design Form. Once they have most of the elements decided, they should begin writing a detailed procedure for their experiment. It is difficult for them to do this because they need to visualize an entire process that *they have not yet done and are only just inventing*. Stay with them here, and let them know that all scientists are continually changing or modifying their procedures.

Approve their materials list and procedural outline before allowing them to begin. The first few days will be spent gathering materials and building their experiment set-ups. Once their experiments are up and running the time spent to monitor them is reduced and there will be time each day for integrating other lessons. Students should be encouraged to come immediately to class, collect data and care for their plants, 10-15 minutes is usually enough. They are 100% responsible for all aspects of their experiment – caring for the plants, collecting and recording data, updating their Experiment Notebooks, modifying procedures, adding to their research paper, designing data collection forms, and thinking ahead to the presentation of their findings to the "scientific community" (their peers).

Closure and Assessment:

Use or modify the Experiment Assessment Rubrics included with this activity. You might create a simpler version of them so that students can assess their peers during the oral presentation.

This is an on-going activity, taking about a week to get started and a minimal amount of time each day thereafter. During the course of this activity there will be a great many life science/botanical topics touched upon by the students during their research – focusing on the concepts they discover is the way to integrate this activity with the regular life science curriculum. Some of the subjects they will naturally "stumble" upon include the following life science topics:

- ❑ Plant life cycles (annual, perennial, biannual)
- ❑ Botanical terms for stems, leaves, flowers and reproductive parts
- ❑ Adaptations to particular niches
- ❑ Plant defense
- ❑ Population dynamics
- ❑ Structure and cellular topics
- ❑ Germination

Because the students are continually refining their question and procedures, and are collecting and organizing data, all leading to supporting or refuting their hypothesis, like real science the activity is continually evolving. Collect their Experiment Notebooks each Friday and use the *Science Experiment Assessment* form to give them weekly reports of their progress and the areas that need to be improved. These assessment forms have been field tested in middle school. Another advantage of the forms is that over time the students start to shift from focusing on "getting an A" to improving particular skills. This shift is critical, for they learn that when they work on improving their skills, an "A" is often the logical consequence, in addition to acquiring a skill that will last a lifetime. The *Science Experiment Assessment Detail* form has been used by students to periodically evaluate themselves and their progress.

Independent Practice and Related Activities:

Many of the students will end up developing highly innovative approaches to the issues of controlling invasive weed species. They should be encouraged to refine, extend, publish and take their innovations into the community through the education of others or with on-the-ground application of their ideas.

Resources:

For getting started on the background information students will need (in addition to their own Internet and library research), try:

U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (2003, June). Fire Effects Information System (FEIS), [Online]. Available: http://www.fs.fed.us/database/feis/ [July 7, 2003]

U.S. Department of Agriculture, National Plant Data Center [Online] http://plants.usda.gov/ [July 8, 2003]

Vocabulary:

During the course of their research and experiments students should maintain a list of new words and create their own vocabulary list to be included in their Experiment Notebooks

National Science Education Standards:

Science as Inquiry - CONTENT STANDARD A:
As a result of activities in grades 5-8, all students should develop
- ❑ Abilities necessary to do scientific inquiry
- ❑ Understandings about scientific inquiry

Life Science - CONTENT STANDARD C:
As a result of their activities in grades 5-8, all students should develop understanding of
- ❑ Structure and function in living systems
- ❑ Reproduction and heredity
- ❑ Regulation and behavior
- ❑ Populations and ecosystems
- ❑ Diversity and adaptations of organisms

Science and Technology - CONTENT STANDARD E:
As a result of activities in grades 5-8, all students should develop
- ❑ Abilities of technological design
- ❑ Understandings about science and technology

Science in Personal and Social Perspectives - CONTENT STANDARD F:
As a result of activities in grades 5-8, all students should develop understanding of
- ❑ Personal health
- ❑ Populations, resources, and environments
- ❑ Natural hazards
- ❑ Risks and benefits
- ❑ Science and technology in society

History and Nature of Science -CONTENT STANDARD G:
As a result of activities in grades 5-8, all students should develop understanding of
- ❑ Science as a human endeavor
- ❑ Nature of science
- ❑ History of science

Teacher's Outline for a Student-Based Inquiry

I Wonder… (One day)

Have the students write an "I wonder…" statement of some control method that would be effective for the invasive weed species they have selected.

Group the "I Wonder…" questions into similar themes based upon control methods (chemical, biological, mechanical, fire or other).

Create scientific teams based upon the various themes and provide each team with an experiment that addresses each theme (or alternatively, students may work individually).

Instruction on experimental design…

(One day)

Provide information on elements of experimentation, including:

- Independent and dependent variables
- Controls
- Hypothesis
- Data Collection

Have the scientific teams identify the above elements for the experiment that they have designed, using the *Design An Experiment Form*

Review of the Literature

(3-5 periods + homework)

From their experiment idea, have the students conduct a review of the literature to research what is known about their particular topic and prepare a report.

Students will include copies of the sources of their information (not a reference list, but the actual articles… this will assist you with assessing their reports to help them with the difference between plagiarism and paraphrasing).

Conduct the Experiment

(6-8 weeks, after a week or two it only takes 10-15/day to record data)

Students will assemble the materials and supplies for their experiment, provide a detail procedure for the experiment, conduct the experiment, and design a data collection process.

Reporting

(Ongoing – research details, procedures refinements, etc. should be upgraded regularly)

Students will write a "scientific paper" to report the results of their experiment to the "scientific community" (the class) and give an oral presentation based upon the following criteria:

- A report of the research and review of the literature behind your experiment, including:
  1. A title page with the name of the project, your name, and date

2. paraphrasing the science you learned from the research
3. copies of the resources you used

- A description of the experiment you conducted, including:
  1. the independent and dependent variables
  2. the control
  3. problems with the experiment (sources of error)
  4. the hypothesis you were testing
- An interpretation of the data collected from your experiment, including:
  1. how you collected the data
  2. a display of the data (charts, transparencies, etc.)
  3. what the data tells you
  4. whether or not your hypothesis was supported
- Implications of the experiment (what new questions arise and how would you use the information gained from the experiment to learn more)
- Any photos or drawings that help illustrate what you did

Design an Experiment

Name: _____ Date:_____

Research Topic (describe in as much detail as possible):

1. Identify the *independent* (manipulated) variable. _____

2. Identify the *dependent* (responding) variable. _____

3. Come up with a *research question*. _____

_____

4. State you *hypothesis*. _____

_____

5. Describe the *materials* you will need to do the experiment. _____

_____

6. On the back of this form, or a separate sheet of paper, write a *procedure* to test your hypothesis. Remember to include safety considerations and a detailed set-up.

7. Identify your *control*. _____

8. Describe the variables that you will hold *constant*. _____

9. On a separate sheet of paper, design a *data table* to collect and display your results.

10. What kind of *graph* or *chart* would you use to present your data? **line/bar/circle**

11. Be ready to graph your data on graph paper. Include a title, labels, and units for the vertical and horizontal axis.

12. Describe the results of your experiment. Did it answer your question? Did it support or disprove your hypothesis? Do you need to re-design the experiment and try again?

Student Experiment Notebook Check-off List

Name: _____ Area of Research _____

Below is a checklist of the different components that I would like you to assemble in a "My Experiment" notebook. Check off each item as you complete it!

_____Your original "I Wonder" question.

_____A report of the research and review of the literature behind your experiment, including:

- A title page with the name of the project, your name, and date
- paraphrasing the science you learned from the research
- copies of the resources you used
- and the following subjects should be addressed:
    - Botanical description
    - Life Cycle of the alien weed species
    - Classification
    - Adaptations
    - Known control methods

You may have already written an initial report about your alien plant. However, as you become involved with your experiment you will find you must learn new skills or details that will necessitate further research. *Those additional aspects should be added to the original research paper*.

_____A description of the experiment you conduct, including:

- the independent and dependent variables
- the control
- problems with the experiment (sources of error)
- the hypothesis you were testing
- Detailed procedures
- Examples of the data collection sheet (preferably done in table form in either Word or Excel)

The procedures should be *very detailed* – a step-by-step outline of everything you have done or will be doing, including a materials list. This is another part of the project that will change and need to be *updated regularly* as you encounter problems or changes to your experiment/research.

_____An interpretation of the data collected from your experiment, including:

- how you collected the data
- a display of the data (charts, transparencies, etc.)
- what the data tells you
- whether or not your hypothesis was supported
- Implications of the experiment (what new questions arise and how would you use the information gained from the experiment to learn more)
- Any photos or drawings that help illustrate what you did

_____ A daily journal that details what you did each day, things you've learned, problems encountered, how you resolved those problems and/or altered the design and procedures, your feelings about the process (frustrations, confusing moments, feelings of success or breakthrough, Ah Ha! Moments, etc.) You should do daily 10-15 minute writings in class, but this should also be followed up at home and on weekends.

_____ All of these components will be bound and organized in a 3-ring notebook with a front cover of your own design, table of contents, etc. The final version will be typewritten but your preliminary rough drafts, hand-written notes, copies or printouts of resources will also be included.

_____ The original rubrics that were scored each time you turned in a draft copy.

_____ Include this check-off sheet with your notebook.

The next check of the Notebook will be _____. The score will be based on this updated check-off list, so everyone knows in advance what is needed!

Date of check-off: _____ Instructor initials here that it was done on time: _____

Science Experiment Assessment

Name:	Experiment Topic:	Date:

SKILLS			
Basic Process - each skill below would score a "5" if all applicable criteria are observed in the student's project			**Score**
Observation	Uses five senses to observe; observes using tools (lens, etc.); identifies properties of an object; uses numbers to describe observations; notes changes in objects; realizes that observation enhances understanding.	Rate 1-5	
Classification	Identifies similarities and differences in properties; identifies properties for sorting; classifies objects or attributes into groups; forms subgroups; has logical rationale for sorting; understands characteristics define sorting systems	Rate 1-5	
Communication	Describes accurately using appropriate vocabulary; asks relevant questions; verbalizes thinking; shares views with others; constructs other means to communicate (reports, media, graphs, etc.)	Rate 1-5	
Measurement	Uses non-standard ways as well as traditional ways to measure; selects appropriate measuring tools; uses tools with precision (i.e., to 10ths in metric); compares and orders objects by weight, length, volume and/or time	Rate 1-5	
Prediction	Performs simple predictions based on inferences; recognizes and extends patterns; shows reasoning in defending predictions; able to blend events, patterns, and data to form ideas of what may happen in the future	Rate 1-5	
Integrated Processes			
Interpreting Data	Able to find meaning or patterns with accuracy between sets of information and use that meaning to construct inferences, predictions, and hypothesis; able to identify a single pattern among objects within an experiment	Rate 1-5	
Controlling Variables	Able to identify variables within an experiment that are to be held constant and those that are to be manipulated; understand the difference between single and multiple variable manipulation	Rate 1-5	
Designing Experiments	Able to visualize the procedures that may be necessary to answer question and plan the appropriate data collection operation; includes a plan to organize data; uses organized, sequential plans to test a hypothesis	Rate 1-5	
Inferring	Uses all appropriate information to form inferences and is able to distinguish non-essential information; develops inferences (ideas) based on observations; able to defend inferences reasonably and logically	Rate 1-5	
Defining Operationally	Able to explain relationships between observed actions to explain phenomena; uses events to describe how something works or doesn't work; is able to find alternative actions from evaluating what doesn't work	Rate 1-5	
Notes:			

RESEARCH	0	1	2	3	4	5	6	Score
Evaluate research paper on the following criteria and provide a single score	No work Completed	Incomplete, poor organization, many misspellings, poor punctuation and plagiarism. Some references	Many details organized, few spelling or punctuation errors, attempts paraphrasing 1-3 references	Good writing skills and use of own interpretation 3 or more references	Progressing - expressing an understanding of concepts with good writing style. References, and some are attached	Proficient - solid expression of concepts, a broad range of information written very well References attached	Exemplary - thorough understanding and expression of concepts, information complete, incorporates prior knowledge, and written creatively and technically. Fully cited as appropriate for scientific papers.	
							Sub-total Score	

JOURNAL	0	1	2	3	4	5	6	Score
Journal is scored according to ONE of the six categories	No journal	Little response and/or the writing is inaccurate or unrelated	The writing shows partial knowledge; lacks detail	The writing is mostly accurate	Shows detail, use of vocab., and a positive attitude	Shows great detail and reflects personal feelings	A coherent whole, personal feelings motivate creative solutions and extensions	

ATTITUDE	(scored as -1 to -5)	1 to 5	1 to 5	1 to 5	1 to 5	1 to 5		Score
Score EACH a value of 0-5 and total	Poor Attitude	Curious	Cooperates	Persists	Open-Minded	Handling Equip.Works Safely		(max. 25)

GENERAL	Poor (0)	Inadequate (1)	Fair (2)	Good (3)	Outstanding (4)			Score
Score general completion in ONE of the five areas	The student did not do the task, did not complete the assignment, or did not show comprehension	The experiment does not accomplish what was asked, contains errors, and/or is of poor quality	The experiment meets most of the criteria and does not contain gross errors or significant omissions	The experiment completely meets the expectations described by the criteria	the experiment meets all criteria, exceeds expectations and shows additional effort	Notes: Criteria for this assessment were provided to the students via the: **Science Experiment Check-off List**		

Score to Grade Conversion:		
A maximum score of 100 points is possible (including bonus points for early turn-in, exemplary presentation of material, or at the discretion of the instructor) A = 90-100 B = 80-89 C = 70 - 79	Total This Page	
	Total Previous Page	
Scores below 70 - Project returned, parents contacted. Project to be re-done by:	Bonus (max. 9)	
	TOTAL SCORE	

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Science Experiment Assessment Detail

Name:	Experiment Topic:	Date:	
	SKILLS		
Basic Process - Describe **specifically** how your experiment allows you to use each skill in the spaces below			**Score**
Observation	Uses five senses to observe; observes using tools (lens, etc.); identifies properties of an object; uses numbers to describe observations; notes changes in objects; realizes that observation enhances understanding.	Rate 1-5	
Classification	Identifies similarities and differences in properties; identifies properties for sorting; classifies objects or attributes into groups; forms subgroups; has logical rationale for sorting; understands characteristics define sorting systems	Rate 1-5	
Communication	Describes accurately using appropriate vocabulary; asks relevant questions; verbalizes thinking; shares views with others; constructs other means to communicate (reports, media, graphs, etc.)	Rate 1-5	
Measurement	Uses non-standard ways as well as traditional ways to measure; selects appropriate measuring tools; uses tools with precision (i.e., to 10ths in metric); compares and orders objects by weight, length, volume and/or time	Rate 1-5	
Prediction	Performs simple predictions based on inferences; recognizes and extends patterns; shows reasoning in defending predictions; able to blend events, patterns, and data to form ideas of what may happen in the future	Rate 1-5	

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Other Notes			
Integrated Processes			
Interpreting Data	Able to find meaning or patterns with accuracy between sets of information and use that meaning to construct inferences, predictions, and hypothesis; able to identify a single pattern among objects within an experiment	Rate 1-5	
Controlling Variables	Able to identify variables within an experiment that are to be held constant and those that are to be manipulated; understand the difference between single and multiple variable manipulation	Rate 1-5	
Designing Experiments	Able to visualize the procedures that may be necessary to answer question and plan the appropriate data collection operation; includes a plan to organize data; uses organized, sequential plans to test a hypothesis	Rate 1-5	
Inferring	Uses all appropriate information to form inferences and is able to distinguish non-essential information; develops inferences (ideas) based on observations; able to defend inferences reasonably and logically	Rate 1-5	
Defining Operationally	Able to explain relationships between observed actions to explain phenomena; uses events to describe how something works or doesn't work; is able to find alternative actions from evaluating what doesn't work	Rate 1-5	

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